Force on EDM Vacuum Chamber Due to Eddy Currents

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In this I note examine the force on the EDM vacuum chamber due to eddy currents from reversing the magnetic field. I assume a box of dimensions length L, width W, and height H. The plate thickness is T. For H $\approx$ W $\ll$ L:

$$V \approx \frac{B}{\tau} LW$$

$$R \approx \frac{2\rho(L+W)}{HT}$$

$$i = \frac{V}{R} \approx \frac{B}{\tau} \frac{LWHT}{\left(2\rho(L+W)\right)}$$

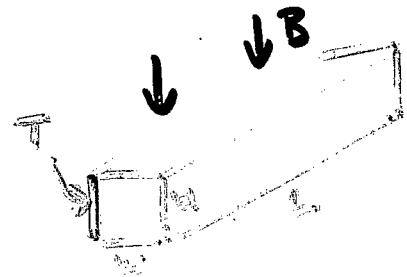$$\frac{F}{L} = iB \approx \frac{B^2}{\tau} \frac{WHT}{\left(2\rho(L+W)\right)}$$

Table 1 shows values used for the calculation, which are only illustrative, ie. not design values. I assumed the vacuum chamber is made of Inconel, the same material as used for the AGS vacuum chamber. Inconel is a high strength, high resistivity stainless steel.

Table 1. Illustrative values used for the calculation.

L	1m
W, H	10cm
T	1cm
ρ	1.29×10^{-6} Ωm
Density	8.44g/cm^3
B	0.3T
τ	0.3s
F/L	10 Nt/m
Weight/L	182 Nt/m

If the magnetic field is right-left symmetric, then the net force on the vacuum chamber is zero. Assuming the magnetic field has a 10% right-left asymmetry, the net force due to the eddy currents is 0.5% of the weight. Even if it isn't bolted down, it wouldn't move

unless the coefficient of friction is less than 0.005. Note that the force passes through zero and changes direction when the field of one polarity is collapsing, and the field of the other polarity is building up. The peak power dissipated is 4W.

We can also consider the force on the electrodes. For this study, I will just use the Inconel numbers. Tom Russo envisioned a sheet metal structure with a strong-back, ie. I beam in the middle. I will assume L = 1m, W = 1cm, H = 5cm, T = 1mm as illustrative values: F/L = 0.06 Nt/m. Now since the width is so small, I will take a right-left magnetic field asymmetry of 10^{-2} giving a net force of 0.0006 Nt/m. If this force is to the right, for example, when the field is collapsing, then it is to the left when the field is building up. These values should be given to an ME.